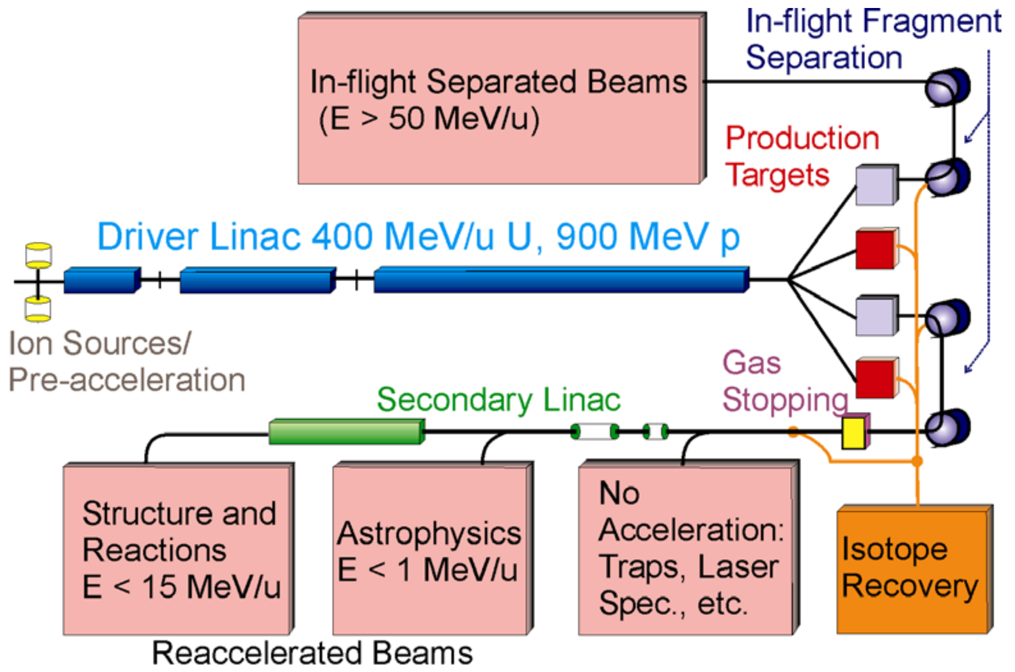
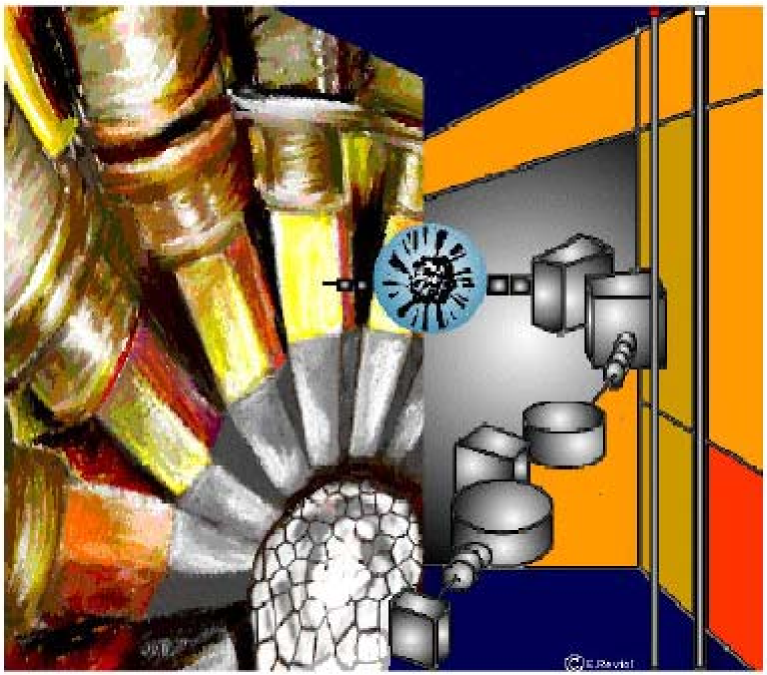
Summary Report from the:

Workshop on the Experimental Equipment for RIA
March 18-22, 2003 ▪ Oak Ridge, Tennessee



Background



<u>Previous Workshop:</u>

Experimental Equipment for an Advanced ISOL Facility,

Lawrence Berkeley National Laboratory

July 22-25, 1998

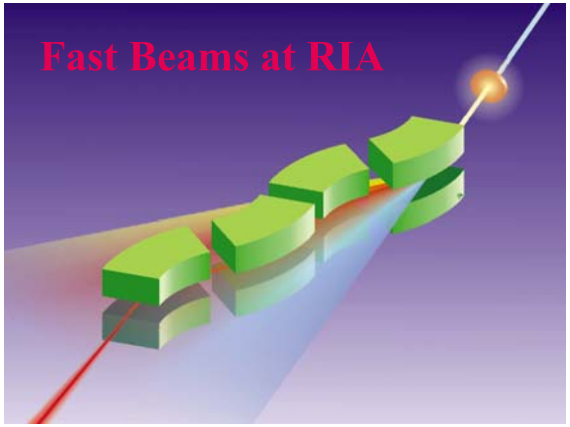
Low Energy Equipment

Table 1: Phase I: Detector Summary (cost in FY98 dollars)

Instrument	R&D			construction		
	FTE	years	cost [M$]	FTE	years	cost [M$]
Gamma-Ray Detectors						
class 1 (CLOVER)				1	1	2.2
class 2 (TRACKING)	8	2	2.5	8	4	20
Recoil Separators						
Low Energy				2	2	3
High Energy				2	2	3.5
Gas-Filled Separator				2	2	1.5
Magnetic Spectrograph						
Conventional Spectrograph				2	2	3
Large Accept. Spectrograph	2	1				
Particle Detectors						
light charged-particle–CsI				1	1	0.25
light charged-particle–Si	2	2	2.0	1	2	0.5
neutron				1	1	0.5
Non-Accelerated Beams						
laser atom trap				4	3	1.1
ion trap				10	2	1.34
nuclear orientation				2	1.5	0.47
beta–NMR				3	1.5	0.36
decay spectroscopy				5	2	0.95
electron-beam ion trap				2	2	0.45
Special Targets						
gas				1	1	0.5
radioactive targets				2	2	0.5
TOTAL	12	–	4.5	49	–	40.12

High Energy Equipment

Equipment item	Use	Cost (M$)
High Bay for 6 experimental vaults, beam lines, vacuum system, utilities	Building plus infrastructure	23
High resolution fragment separator	In-flight separation of fast fragments	17
Velocity (Wien) Filter	Additional removal of contaminants, especially at lower velocities	10
High resolution spectrograph	Precision particle detection for direct reactions in inverse kinematics, e.g., knockout and charge-exchange studies.	18
Sweeper magnet	Neutron measurements at zero degrees (needed to deflect intense charged particle flux from line-of-sight of neutron wall)	5
Large Area Neutron Detector	Structure of neutron-rich nuclei, EOS	2
Position sensitive Ge-array	Coulomb excitation, tagging of knockout reactions, decay studies	10
Large area Si-array	Inverse kinematics studies	3
Implantation Station	Half lives, decay modes	1
Time Projection Chamber	EOS, quantum transport phenomena	4



March 2000

NSAC RIA Costing Sub-Committee

The "trust fund" approach to experimental equipment is now common for a facility of this scale and type, and is appropriate given the expected evolution in both scientific priorities and technical capabilities over the life of this project. The overall allocation of funds to experimental equipment is in line with what will be required to address the scientific scope desired by the potential RIA user community. Any significant cost reductions in experimental equipment are likely to require a reduced scope of the scientific program. Indeed it is likely that as the radioactive beam nuclear physics evolves worldwide, while RIA is under development, **that increased demand for instrumentation funding will develop**. The resulting pressure, if it cannot generate increased funding for experimental equipment, may result in a smaller number of endstations and consequently will require careful identification of scientific priorities.

The Sub-committee finds the **$94M** 'trust fund' allocated for experimental equipment to be reasonable for the intended goal. In the sub-committee's opinion these costs should be considered fixed with the scope adjusted to maintain costs.

January 2001

NSAC RIA Costing Sub-Committee
Overview of the Rare Isotope Accelerator

- ***General-purpose equipment***
  - Gamma-Ray Detectors
  - Charged-Particle Detectors
  - Special targets
- ***Stopped-beam area***
  - Laser atom trap
  - Ion trap
  - Electron beam ion traps,
  - Beta-gamma coincidence setup
  - Nuclear orientation
  - Beta-nuclear magnetic resonance facilities
- ***Low-energy area***
  - Recoil Separator System
- ***Medium-energy area***
  - Recoil Separator System
  - Gas-filled Magnetic Separator
  - Magnetic Spectrograph
- ***High-energy area***
  - Magnetic Spectrograph
  - Time-projection Chamber

RIA is Different from JLAB and RHIC

- Experiments are not based on a few large detectors
- Several different spectrometers have to be combined with several different detector arrays in different configurations
- Balance between construction of several dedicated devices and flexibility of sharing one device in different configurations
- In principle, existing detectors could be used at RIA
- Experiments at current radioactive beam facilities continue to improve the unique requirements of radioactive beams
- Requirements for low intensity beams are the same at the present facilities and RIA
- R&D needed for development of high intensity radioactive beams
    - High rate beam tracking detectors
    - High background radioactivity at target

Organization of the Workshop

Six Working Groups:

1. Advanced Concepts in Gamma Ray Detection (D. Cline)
2. Neutron and Charged-Particle Detectors (W. Lynch and D. Sarantites)
3. Magnetic Devices and Separators (J. Nolen and B. Sherrill)
4. Experiments with Non-Accelerated Beams (P. Mantica and G. Sprouse)
5. Advanced Electronics and Data Acquisition (D. Radford)
6. Advanced Targets (D. Shapira and W. Loveland)

Advanced Concepts in Gamma Ray Detection

Summary of γ-ray detectors required for RIA

1: 4π Ge tracking array, GRETA

- GRETA will have orders of magnitude greater sensitivity and resolution and will be absolutely central to science at RIA
- GRETA must be modular, and easy to relocate plus set up subsections
- Additional tracking detectors will be needed to supplement GRETA to serve simultaneous multiple beams.

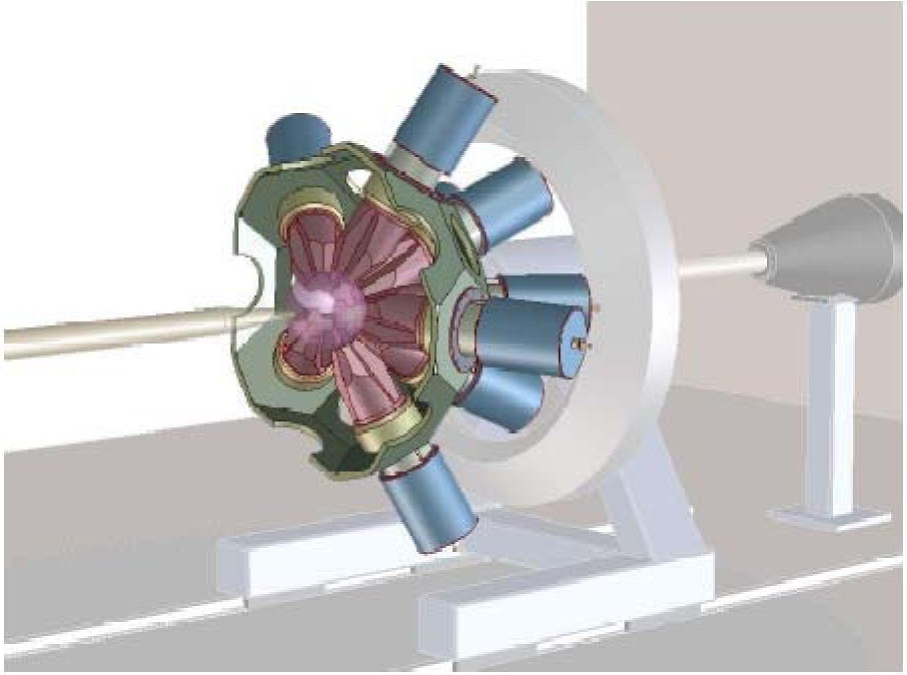
2: Special purpose γ-ray detectors

- Arsenal of versatile and flexible gamma ray detectors, that can be used both for dedicated and general experiments.
- Many detectors already available can be used.

3: Additional R&D

- Ge tracking detectors; prototyping, characterization, electronics, tracking algorithms
- Investigate wide band-gap semiconductors [CdZnTe, HgI_2], and new scintillators

GRETINA



Proposal for Gretina

June 2003

New Funds (FY03 k$): 15,042

Cost Summary

	$M
1: 4π Ge tracking array, GRETA	60.1 [TPC]
2: Dedicated gamma detector systems:	
High resolution, compact arrays for decay spectroscopy	2.5 *
Medium resolution high efficiency array [BaF_2, new scintillator]	5.0
Additional coaxial Ge tracking detectors	?
Total absorption spectrometer	0.5*
NaI anticoincidence barrel	0.1*
Many smaller X-ray and gamma detectors	?

* Included in Decay and Fundamental Interactions summary

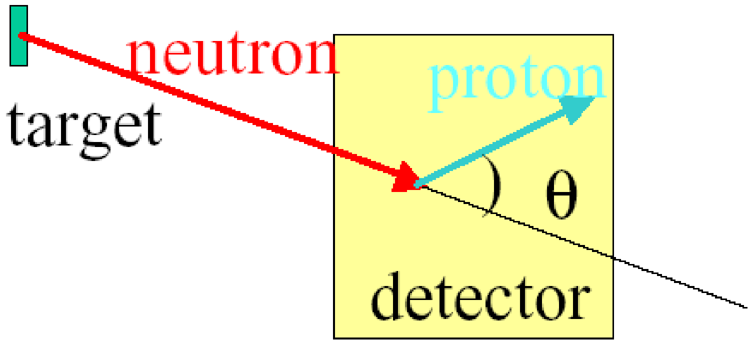
Neutron and Charged-Particle Detectors

- TPC + TP-MUSIC for EOS studies
- MUSIC for fragment separator
- High energy neutron detector
- Low energy neutron detectors
  - with tracking
  - without tracking
- 4π silicon strip detector arrays
  - For fast beams at E/A >200 MeV
  - For low energy beams
- Active gas targets/detector systems

More than $1M

Could be more than $1M

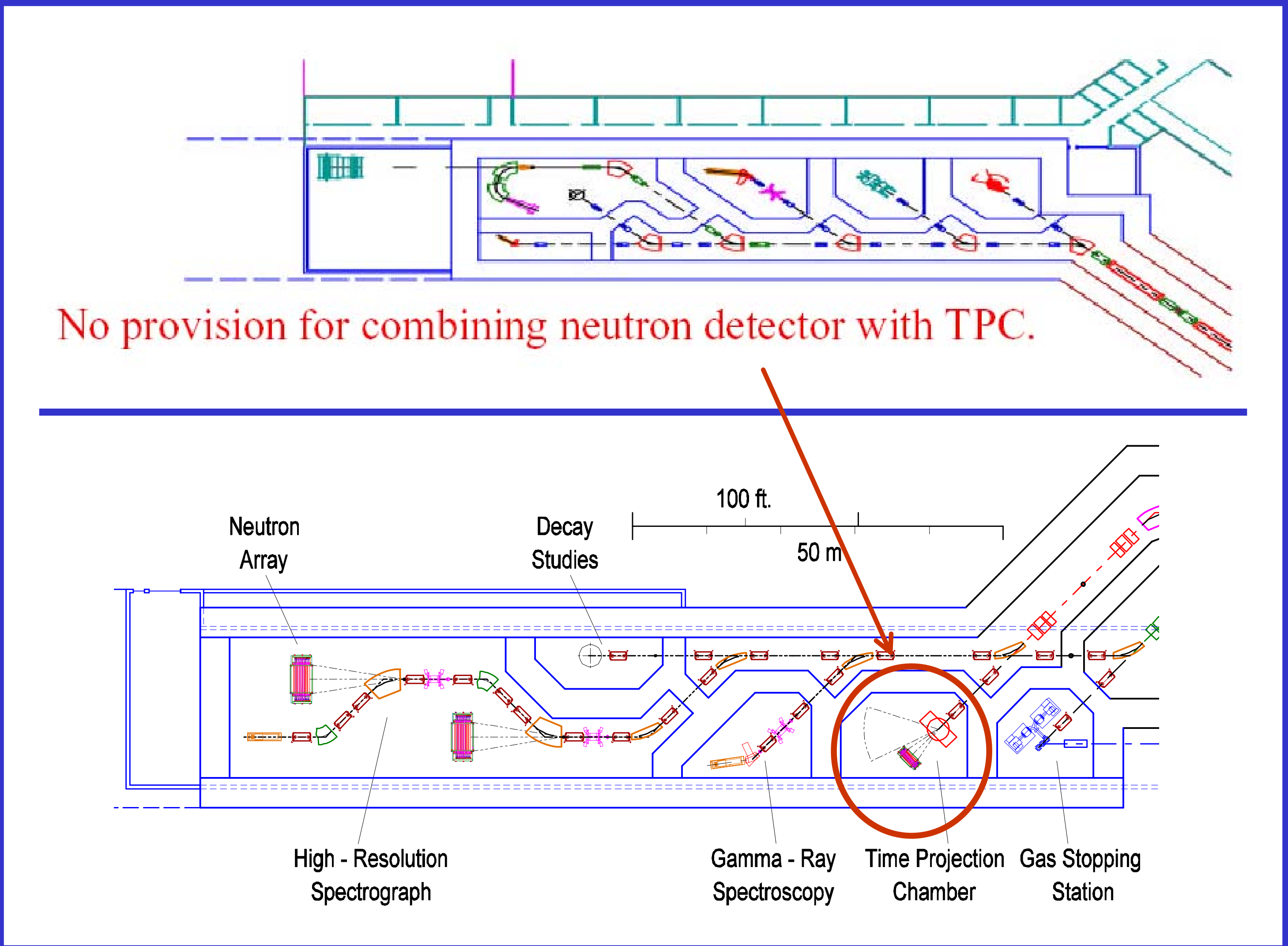
Neutron Tracking Detector



$$E_n = \frac{E_p}{\sin^2 \theta}$$

Measure neutron energy and angle from track of "first" proton

Floor Plan Issues



R&D Needs

- ASIC readout for silicon and scintillator arrays.
- Pulse shape discrimination for silicon.
- Neutron tracking detectors.
- High speed beam tracking detectors:
  - Diamond and Channel plate detectors

- Whether or not detectors use these technologies has an impact on the RIA floor plan, beam lines and their foreseen utilization.

- There is an urgent need for (RIA?) research and development money to explore and develop these technologies:
  - $0.5M/year

Cost Summary

TPC + TP-MUSIC	\$3.7 MD (\$2.5MD Magnet)
4π Silicon Ball	\$2MD
H.E. Neutron Detector	~\$2MD
Neutron tracking Array	\$5 MD?
Active target	\$0.3 MD
Low Energy arrays	\$0.5 MD
TOTAL	\$13.5MD

- Spectrometer focal plane detectors not included in cost estimate.
- Cost of neutron tracker highly uncertain.

Magnetic Devices and Separators

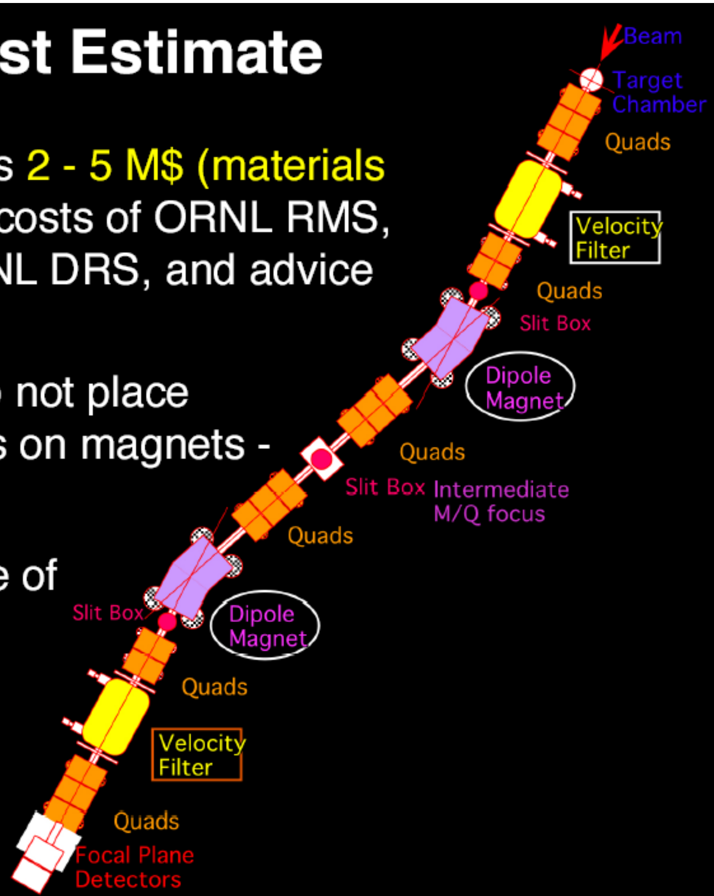
- Spectrometer(s) and Separator(s) for low, medium and high energies
- Recoil separators
- Gas-filled separators
- Velocity filters

- Devices require large areas
- Additional space for auxiliary detectors at different locations
- Shielded dump for unused (radioactive) beam
- Early design decisions, to determine floor space
- Astrophysics, spectroscopy, and heavy element programs have conflicting requirements for separator design - *e.g.* phase space acceptance, so . . .

Dedicated Low-Energy Separator

Cost Estimate

- Rough cost estimate is 2 - 5 M$ (materials plus labor), based on costs of ORNL RMS, TRIUMF Dragon, ORNL DRS, and advice from experts
- Low energy beams do not place stringent requirements on magnets - reasonable cost
- Increasing acceptance of device increases cost
- Cost kept low by utilizing surplus equipment



Capture measurements are long (> weeks)

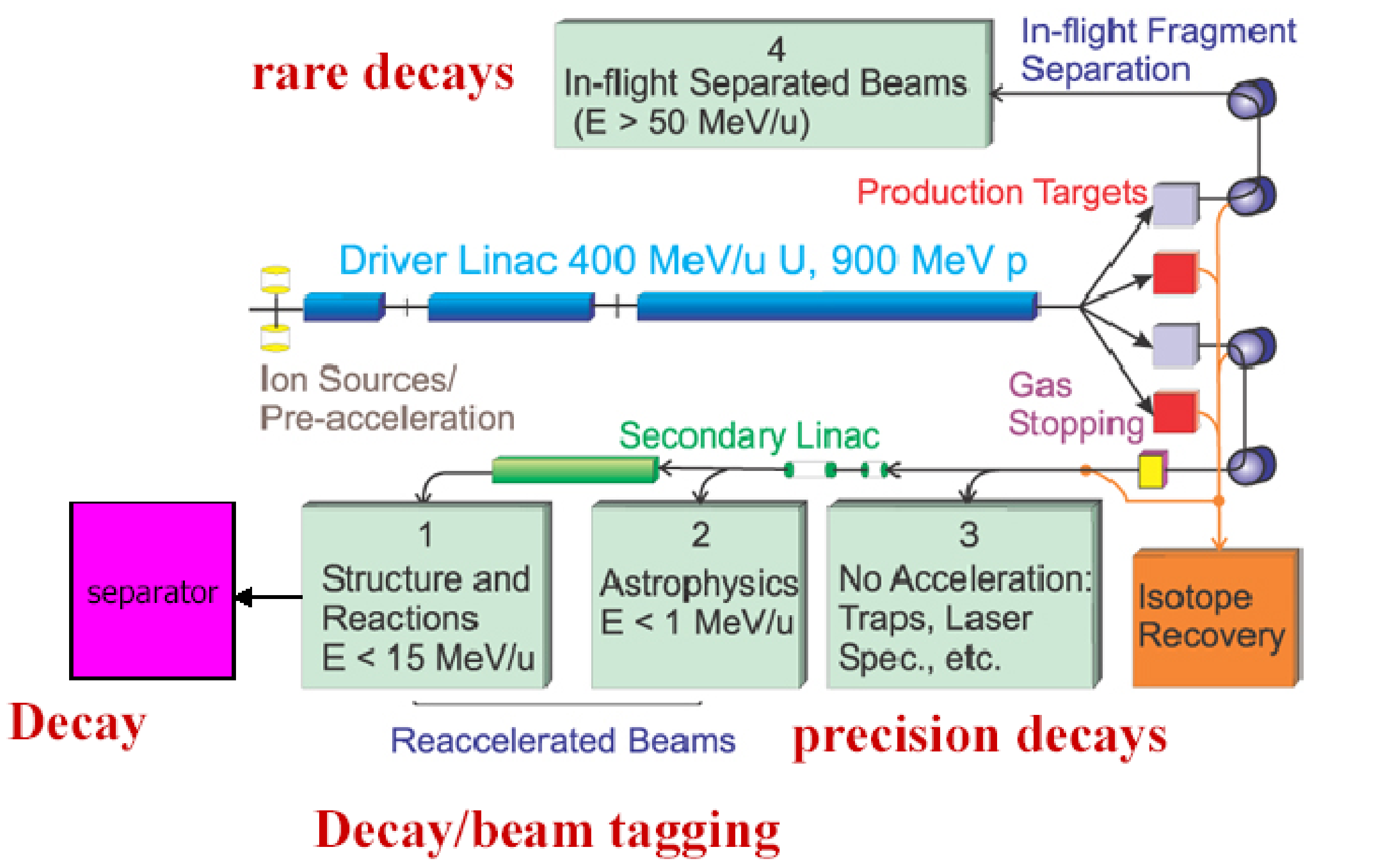
Dedicated device enables simultaneous running

Cost Summary

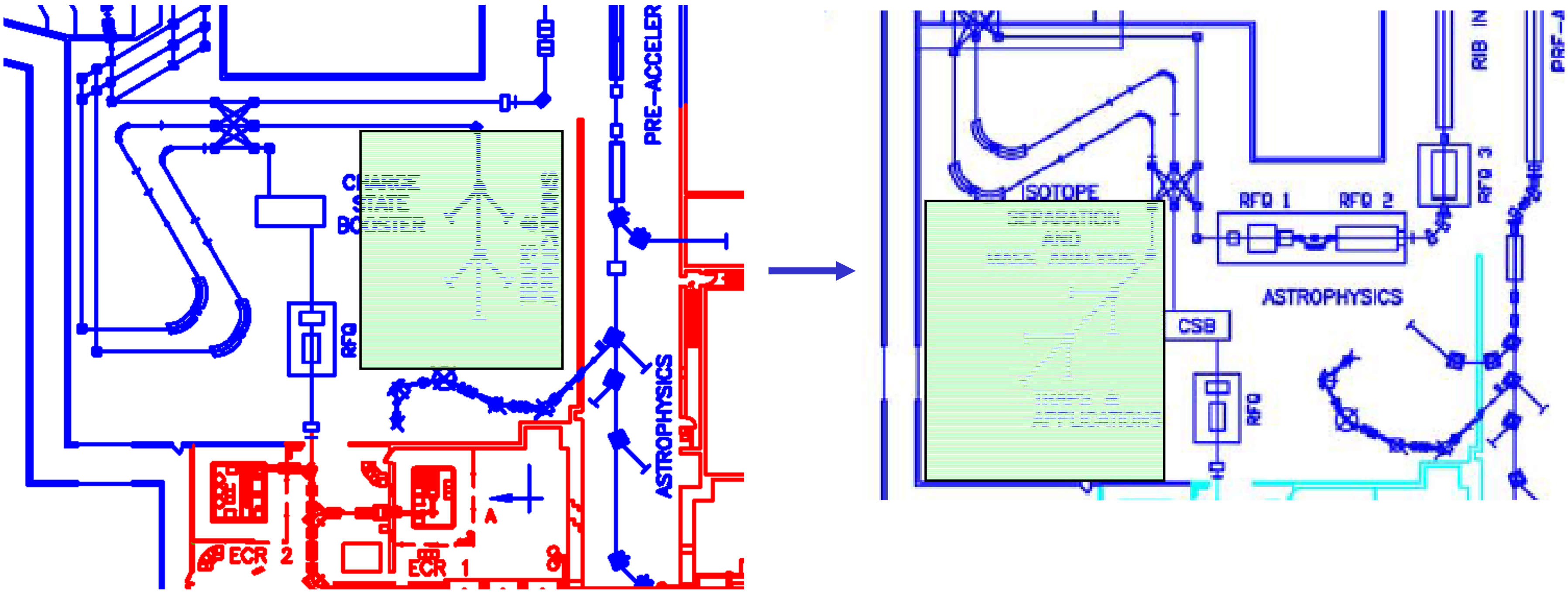
Low-energy Recoil Separator	$4M
Medium Energy Recoil Separator	$4M
Gas-filled Separator	$2M
Low-energy Spectrometer	$4M
High-Energy Spectrometer	$18M
Sweeper	$5M

Experiments with Non-Accelerated Beams

Overlap in Several Areas: Decay Spectroscopy

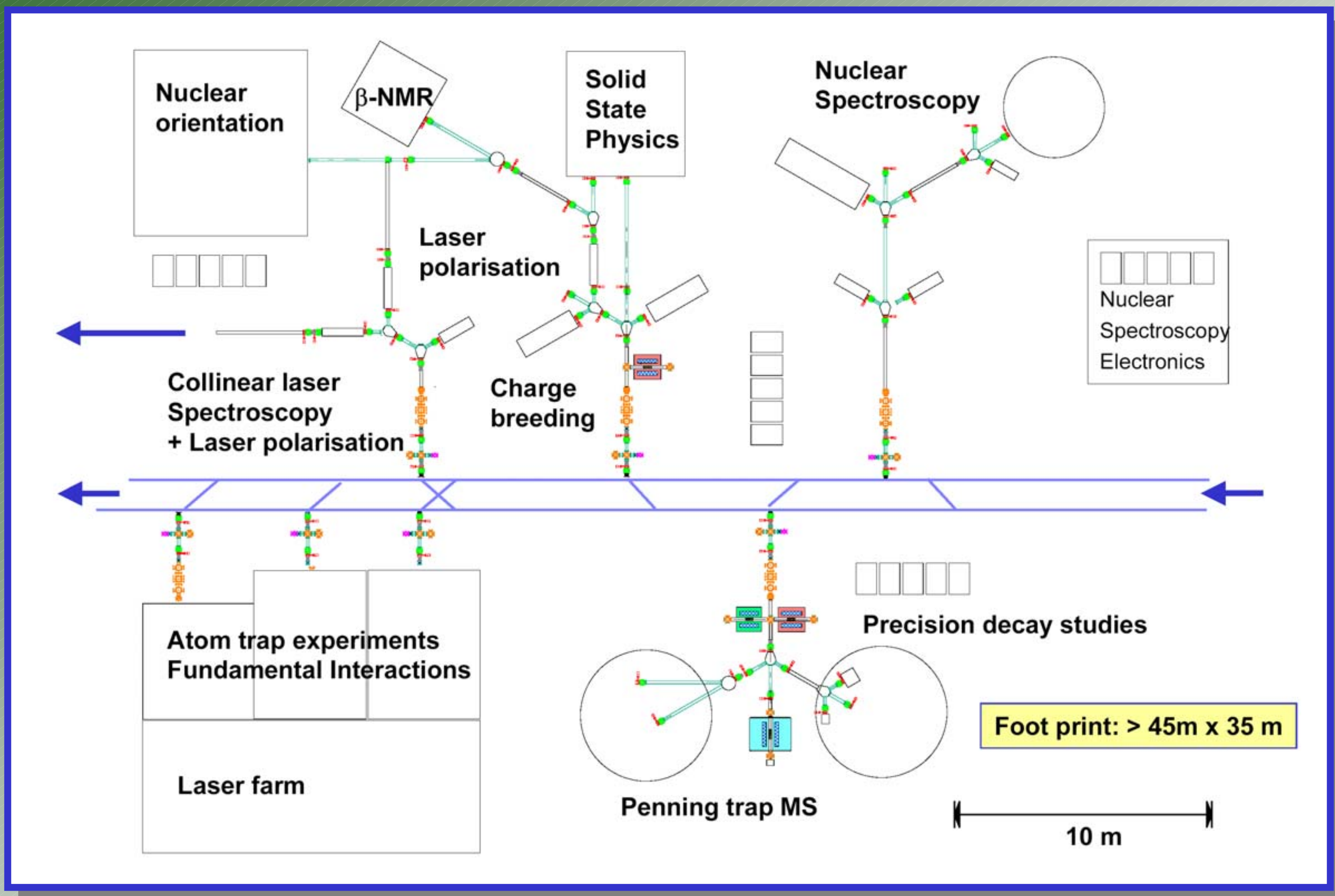


Space and Flexibility



Influence on Layout of the Facility

Low-Energy Beam Area



Cost Summary

γ-decay	dedicated Ge for rare decay	2.5 M	2
(4.8 M, 13.5 FTE)	dedicated Ge for precision decay	?	?
	TAS	0.5 M	2
	BaF2 (fast timing)	0.2 M	1
	NaI (anti coincidence)	0.1 M	1
Charged Particle		0.5 M	1
Neutron		0.6 M	4
Ion manipulator	(MTOF)	0.4 M	2.5
β-NMR (2)		0.4 M	2
Nuclear Orientation		0.8 M	3
Solid State Physics	(incl beam polarisation)	2M	4.5
Fundamental Interactions/Atom traps	(three stations + laser farm)	2.1M	3
Collinear Laser spectroscopy		0.5 M	2
Beam lines	(150m)	7.5 M	2
Beam cooler + test beams (4)		0.9 M	1
Beam polarizer		0.4 M	1
Charge booster (2)		0.9 M	1
Isobar separator		0.4 M	1
Penning trap		1 M	2
e-ν trap (Witch)		1 M	2

Lowest energy experiments

Total: 22.7 M + 38 FTE

+ trap after RMS

Advanced Electronics and Data Acquisition

- Digital Pulse Processing (DPP)
- Application Specific Integrated Circuit (ASIC)
- Needed for GRETA and particle arrays
- Goal to reduce cost per channel
- R&D essential for effective utilization of RIA

Advanced Targets

Gas targets (windowless / gas jets / plasma)	1.2M
Cryogenic targets (extrusion / other)	0.5M
Active targets (tracking / timing)	<<1M
Polarized targets	0.5M

Preliminary Conclusions

- No high priority immediate R&D for experimental equipment for RIA
- Large devices influence layout of facility
- Many (large complicated) devices have to be movable
- Allow for different combinations of devices
- Space and time for debugging and repair
- Space for potential future expansion
- Current R&D activities concentrate on GRETA, DPP, ASIC
- Floor plan decision soon because it influences overall RIA design
- Physics driven: which device do we need to get the physics done
- More details in the reports written by the working groups
- More (Final?) discussions at the:

Announcement

“RIA Facility Workshop”

January 6-10, 2004

East Lansing, Michigan

Acknowledgments

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